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REMARKS

In the last Office Action, dated February 20, 2001, claims 1, 3, 8 and 9 were rejected under 35 U.S.C. §102(a) as being clearly anticipated by Takagi ('360). Claim 2 was rejected under 35 U.S.C. §102(a) as being anticipated by each of Katsuma, Hirano and Mukohjima. Claims 4-6 were rejected under 35 U.S.C. §103(a) as being unpatentable over Takagi ('360). The Examiner stated that Takagi teaches the claimed ultrasonic motor structure except that the support 30 is not disclosed as being an integral part of the substrate 50. The Examiner took the position that it is within the skill expected of the routineer to make parts integral or separable.

Claim 7 was rejected under 35 U.S.C. §103(a) as being unpatentable over Miyazawa, Katsuma or Hirano in view of Wada, Kumasaka ('179) or Kumasaka ('909). The Examiner stated that each of the references to Miyazawa, Katsuma and Hirano discloses an ultrasonic motor mounted on a printed circuit board but does not explicitly teach that drive circuit elements are also provided on the board. The Examiner pointed out, however, that Wada and Kumasaka teach that it is well known to place the drive circuit for a piezoelectric device on

the same circuit board that supports the device to save space and make solid state manufacturing and connections more easy. In view of this disclosure, the Examiner has taken the position that it would have been obvious to one of ordinary skill in the art that the printed circuit boards of Miyazawa, Katsuma or Hirano could be expanded to include drive circuit elements.

In addition to the foregoing rejections, claims 10-13 and 17-21 were rejected under 35 U.S.C. §102 as being unpatentable over Toda, Vishnevsky ('580), Kumada or Vishnevsky ('073); claims 14 and 15 were rejected under 35 U.S.C. §103 as being unpatentable over Vishnevsky ('073) or Toda; and claim 16 was rejected under 35 U.S.C. §103 as being unpatentable over Vishnevsky ('073) or Toda in view of Wada, Kumasaka ('179) or Kumasaka ('909). The Examiner stated that Vishnersky ('073) and Toda teach the vibration motor but not mounted on a PCB which, for the same reasons given in regard to claim 7, would have been obvious to provide in Vishnersky or Toda with a PCB substrate.

By the present response, independent claims 1, 10 and 20 have been amended to more particularly point out and distinctly claim the novel subject matter of the present invention. Amended claims 1 and 20 further recite that the substrate has a conductor pattern for conveying a drive signal from a drive circuit, and that the support member mechanically

supports the piezoelectric element on the substrate and transmits the drive signal from the conductor pattern formed on the substrate to the piezoelectric element. Amended independent claim 10 now recites that the structure of the piezoelectric vibrator, i.e., that the vibrator is a laminated structure formed of one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal and one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and further recites that the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member.

Submitted herewith is an attachment captioned **"Version With Markings to Show Changes Made"** including marked-up versions of claims 1, 10 and 20 showing the changes made thereto by the present response. In response to the Examiner's request for a substitute specification, applicants have also submitted herewith a substitute specification consisting of the original specification re-typed in smooth form to incorporate revisions made thereto during prosecution. Also enclosed is a marked-up scanned version of the original specification showing the changes made thereto. Applicants'

undersigned attorney hereby states that the substitute specification does not contain impermissible new matter.

To obtain a fuller scope of coverage, new claims 22-32 have been added. Adequate support for the subject matter recited in these claims may be found in the specification as originally filed.

Applicants respectfully submit that claims 1-21 and newly added claims 22-32 patentably distinguish over the prior art of record.

As described by applicants at pages 1-2 of the specification, the conventional piezoelectric ultrasonic motor utilizes conductive wires as signal transmitting means for conveying a drive signal produced by a drive circuit to the piezoelectric element. Typically, an elastic member such as a spring is used to bias the piezoelectric element against a movable member to efficiently transmit drive power produced by vibration of the piezoelectric element to the movable member so as to drive the moving member. When such an ultrasonic motor is mounted on a circuit board, it is held to the board by a support member that holds the piezoelectric element in place.

In the conventional ultrasonic motor it is necessary to include conductive wires as signal transmission means, support means for holding the piezoelectric element in place with respect to the movable member, and an elastic member for

maintaining a biasing force between the piezoelectric element and the movable member. This structure is needed to support and hold the piezoelectric element in a given position with respect to the movable member and to transfer a drive signal to the piezoelectric element. The use of separate components to accomplish these tasks leads to an increase in the size of the ultrasonic motor. In addition, since loss in the expansion-and-contraction movement of the piezoelectric element occurs through both the support member and the conductive wires, the use of separate components results in an increased loss.

The present invention overcomes the foregoing problems by providing an ultrasonic motor with a support member capable of serving two or more of the aforementioned functions. According to the present invention, the support member not only supports the piezoelectric element on a substrate, but also has the ability to transmit a drive signal to the piezoelectric element so that no conductor wires are needed. The support member thus transmits the drive signal to the piezoelectric element. In addition, the support member can be formed of a resilient material or a flexible portion so that it resiliently urges the piezoelectric element against the movable member, thereby eliminating the need for a separate elastic member for biasing the piezoelectric element and movable member. Accordingly, the present invention makes

it possible to substantially reduce the size of the ultrasonic motor and reduces the loss associated with the use of multiple components as described above.

An embodiment of the inventive ultrasonic motor is shown in Fig. 1 of the application drawings. The motor includes a rectangular piezoelectric element 10 that receives a drive signal X to undergo elliptical vibration. Support members 11, 11 hold the piezoelectric element 10 on a substrate 7 and deliver signals through signal lines 7a, 7b printed on the substrate 7. A symmetry member 12 has a movable member 12a in contact with an end of the piezoelectric element 10. A drive circuit IC 6 is provided on the substrate 7 to supply the drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and conductors formed on the support members 11, 11.

In operation, the ultrasonic motor 1 operates by elliptic vibration of the end face of the piezoelectric element 10 produced in response to the drive signal X to move the movable member 12a in a direction parallel to the end face.

The support members 11, 11 may be formed of a resin material in an L-shaped form and each may be provided with three signal lines formed on a surface thereof. The support members 11, 11 have six signal lines and six corresponding

electrodes are formed on side faces of the piezoelectric element 10.

The support members 11, 11 have one side 11a fixed to the signal line 7a of the substrate 7, such as by solder, and the other side 11b fixed to a side of the piezoelectric element 10 by means of a conductive adhesive or the like. The support members 11, 11 thus hold the piezoelectric element 10 to the substrate 7 and connect between electrodes of the piezoelectric element 7 and the signal lines 7a or 7b. The support members 11, 11 thus serve to support the piezoelectric element and further serve as signal transmission means for transmitting the drive signal X to the piezoelectric element 10. As a result, the number of components of the ultrasonic motor is reduced, and the size and loss factor of the motor are also reduced.

The piezoelectric element 10 has a first piezoelectric vibrator 14 serving as a flex vibration source and a second piezoelectric vibrator 15 laminated thereon and serving as an expansion-and-contraction vibration source. The piezoelectric element 10 has electrodes 13a-13f respectively connected to the six electrodes on the substrate 7 and the support members 11, 11 to cause the respective vibrators 14, 15 to undergo vibration. This combination of vibration sources produces the elliptical motion of the piezoelectric element 10.

The cited references fail to disclose the subject matter recited by amended independent claims 1, 10 and 20, or much of the subject matter recited in various ones of the dependent claims.

Amended claims 1, 10 and 20 each recite subject matter that is not disclosed in the cited references. As pointed out above, amended claims 1 and 20 recite that the substrate has a conductor pattern for conveying a drive signal from a drive circuit, and that the support member mechanically supports the piezoelectric element on the substrate and transmits the drive signal from the conductor pattern formed on the substrate to the piezoelectric element.

Amended independent claim 10 recites that the piezoelectric vibrator is a laminated structure formed of one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal and one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and further recites that the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member.

Claims 1, 3, 8 and 9 are not anticipated by Takagi '360 since the cited reference to Takagi '360 requires the use of conductive wires in addition to a support member extending

from a substrate to support a piezoelectric element and transmit a drive signal to the piezoelectric element. Amended independent claim 1 explicitly recites that conductive wires are not used for this purpose and that the support member transmits the drive signal.

Similarly, none of the cited references to Kutsuma, Hirano, Mukohjima, Miyazawa, Katsuma, Hirano, Wada, Kumasaka ('179), Kumasaka ('909), Toda, Vishnevsky ('580), Kumada, or Vishnevsky ('073) discloses or suggests an ultrasonic motor which eliminates the need for the use of conductive wires extending from a drive circuit to a piezoelectric element. Nor do these references, alone or in combination, disclose or suggest the structure of the piezoelectric element recited in amended independent claim 10.

With respect to the Examiner's conclusion that it is within the level of routine skill to make parts integral or separable, applicants respectfully point out that the claims do not recite structure that is the mere integration of separate parts. Amended claims 1 and 20 require a substrate having a conductor pattern for conveying a drive signal from a drive circuit, a piezoelectric vibrator provided on the substrate, and a support member for supporting the piezoelectric vibrator and transmitting the drive signal to the piezoelectric vibrator. Nothing in the cited references would have suggested this combination of elements.

Anticipation under 35 U.S.C. §102 requires the identical disclosure by a single prior art reference of all elements of a rejected claim arranged exactly as recited in the claim. W.L. Gore & Associates v. Garlock, Inc., 220 USPQ 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) ("Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration"); Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 USPQ 481, 485 (Fed. Cir. 1984) ("Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim") (emphasis added).

Since Takagi (360), Kutsuma, Hirano and Mukohhima fail to identically disclose the subject matter recited in amended independent claim 1, the anticipatory rejection of claims 1, 3-6, 8 and 9 should not be maintained.

An obviousness rejection requires a showing that each and every limitation in a rejected claim would have been obvious, and must be based on a showing in the prior art of some teaching, reason, suggestion, or motivation to make a modification which renders an invention obvious within the meaning of 35 U.S.C §103. See, e.g., Symbol Technologies, Inc. v. Opticon, Inc., 935 F.2d 982, 989, 18 USPQ2d 1885 (Fed. Cir. 1991). The cited references fail to identically disclose the subject matter of claims 1, 10 and 20, and fail to support

the conclusion that the modifications needed to replicate the combinations recited in claims 1, 10 and 20 would have been obvious. As described above, the ultrasonic motor of claims 1 and 20 is provided with a support member that transmits a drive signal to the piezoelectric element and no conductive wires are used. The inventive ultrasonic motor of these claims has an improved driving force, a reduced vibrational loss and smaller dimensions as compared with conventional ultrasonic motors. In the Fig. 1 embodiment, the piezoelectric vibrator 10 generates a rotational driving force in response to a received drive signal. A drive signal for driving the piezoelectric element 10 is transmitted along leads 7 to a support member 11. The support member 11 supports, and is in electrical connection with, the piezoelectric vibrator 10 on the substrate 8. Thus, the support member is effective for both supporting the piezoelectric member 10 and for transmitting the drive signal from a conductor pattern formed on the substrate to the piezoelectric vibrator 10. The movable member 12 contacts the piezoelectric vibrator 10 and moves in response to the vibrational driving force. There is simply no teaching or motivation in the references for making any of the modifications necessary to achieve the claimed combinations. Thus, there is no support for a continued obviousness rejection of the claims.

Moreover, various dependent claims define separately patentable subject matter. In one embodiment of the inventive ultrasonic motor, the support member is comprised of an elastic material effective to elastically urge the piezoelectric vibrator against the movable member. Nothing similar is found in the cited references. The support member may include a relatively thinner constriction portion and a relatively thicker connection portion, the constriction portion being effective for decreasing vibration losses. This is effective to provide the resilient biasing force.

The support member may also be incorporated as part of the substrate, wherein the substrate has a recess portion in which the piezoelectric vibrator is disposed to reduce the overall thickness of the motor. No corresponding structure is found in the cited references. Also, the support member may be configured for supporting the piezoelectric vibrator at a flex vibration node of the piezoelectric vibrator to reduce vibrational loss.

Thus, in accordance with the present invention an improved ultrasonic motor is provided having reduced vibrational loss, smaller dimensions and improved driving force as compared with the conventional art. The inventive ultrasonic motor may be incorporated in an electronic appliance, such as (but not limited to) an electronic

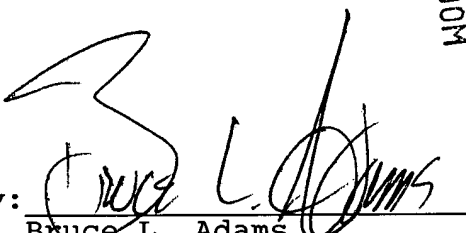
timepiece, a measuring instrument, a camera, a printer, a printing machine, a machine tool, a robot, a moving apparatus and a memory device.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for allowance. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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Attorneys for Applicants

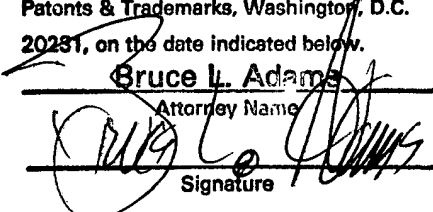
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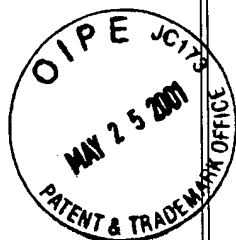
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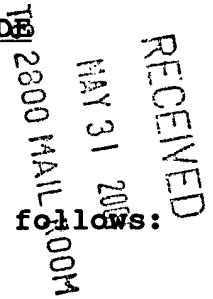
VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 1, 10 and 20 have been amended as follows:

1. (Twice Amended) An ultrasonic motor, comprising:
a movable member disposed to undergo movement in response to a
drive force; a substrate having a conductor pattern for
conveying a drive signal from a drive circuit; a piezoelectric
vibrator provided on the substrate for undergoing oscillating
movement in response to the [an input] drive signal so as to
contact the movable member and generate the [for generating a]
drive force to drive the movable member; and a support member
provided on the substrate for mechanically supporting the
piezoelectric vibrator on the [a] substrate and transmitting
the drive signal from the conductor pattern [, the support
member having a signal transmission function to transmit the
drive signal] to electrodes of the piezoelectric vibrator so
that no conductor wires extend from the substrate to connect
the drive circuit and the piezoelectric vibrator.

10. (Amended) An ultrasonic motor, comprising: a
substrate; a piezoelectric vibrator disposed on the substrate
to undergo vibration in response to a drive signal; a support
member for supporting the piezoelectric vibrator on the



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substrate, the support member being effective to transmit the drive signal to the piezoelectric vibrator; and a movable member disposed on the substrate adjacent [in contact with] the piezoelectric vibrator and driven in response to vibration of the piezoelectric vibrator; wherein the piezoelectric vibrator comprises one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal laminated to one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member.

20. (Amended) An electronic appliance incorporating an ultrasonic motor, comprising: an ultrasonic motor comprising a movable member disposed tor undergo movement in response to a drive force, a substrate having a conductor pattern for conveying a drive signal from a drive circuit, a piezoelectric vibrator disposed on the substrate to undergo vibration in response to the [a] drive signal so as to contact the movable memver and generate the drive force to drive the movable member, a support member provided on the substrate for mechanically supporting the piezoelectric vibrator on the substrate and transmitting the drive signal from the conductor

pattern [, the support member being effective to transmit the drive signal] to electrodes of the piezoelectric vibrator so that no conductor wires extend from the substrate to connect the drive circuit and the piezoelectric vibrator; [, and a movable member disposed on the substrate in contact with the piezoelectric vibrator and driven to undergo movement in response to vibration of the piezoelectric vibrator;] an output mechanism for outputting a motion; and a transmission mechanism for transmitting movement of the movable member to the output mechanism.



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1 **ULTRASONIC MOTOR AND ELECTRONIC APPLIANCE**
2 **WITH ULTRASONIC MOTOR**

3 BACKGROUND OF THE INVENTION

4 1. Field of the Invention

5 ~~[This]~~ ^{The present} invention ~~[relates]~~ ^{pertains} to ultrasonic motors used for
6 timepieces, cameras, printers, memory devices and so on, and
7 more ^{More} particularly, ^{the present invention pertains} to ~~a~~ ^{an} ultrasonic motor ^{with} which is reduced ~~[is]~~
8 vibration ^{more} ~~[leak]~~ to efficiently transmit a drive force to a moving
9 member, ^{inefficiency} but made ~~in~~ small in size with improved reliability.]

10 2. Description of the Related Art

11 ~~[The]~~ ^{A conventional} ultrasonic motor utilizes, as power to move a moving
12 member, elliptic vibration that is a resultant vibration of
13 expansion-and-contraction vibration and flex vibration caused
14 on a piezoelectric element applied by a drive signal such as
15 an alternating current voltage. Recently, ~~(attentions]~~ ^{attention has} have
16 ~~[being]~~ ^{been} drawn to ~~[the]~~ ultrasonic motors particularly in the field
of micro-mechanics, because of their high electric-to-
mechanical energy conversion efficiency.

17 ~~[The]~~ ^{A conventional} ultrasonic motor generally has a piezoelectric
element as a drive power source, a signal transmission means
for transmitting drive signals to the piezoelectric element,
and an elastic member for pressure-contacting the
piezoelectric element with the moving member to efficiently
transmit drive power to the moving member.

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Where such a ultrasonic motor is installed on a circuit

2 board, such as a printed circuit board, it is held on the circuit

3 board by [using] a support member [to hold one part of a vibrator]

4 [having a] piezoelectric element [for] the ultrasonic motor.

5 However, [there has been a necessity] ^{that holds the} ^{of} for the conventional

ultrasonic motor to provide the piezoelectric element with a

7 signal transmission part, such as conductor wires, to apply ^a

8 drive signal to the piezoelectric element. [That is] [there] ^{As a result}

9 [encountered] [leakage] ^{loss} of the expansion-and-contraction ^{occurs}

10 vibration and flex vibration [caused on the piezoelectric

11 element to an outside] through both the support member and the

12 signal transmission part. [The] ^{In addition} [leakage] ^{loss} of expansion-and-

13 contraction vibration and flex vibration [was] also [through the

14 elastic member [to the outside]. ^{occurs}

15 As a result, [the] ^a conventional ultrasonic motor [could] ^{does} not

16 efficiently transmit drive force to the moving member, [and] thus

17 [impaired in ultrasonic motor characteristic of high] impairing the

18 electric-to-mechanical energy conversion [efficacy].

19 ^{Further} [Meanwhile], mounting a plurality of elements on the

20 piezoelectric element [prevented against] ^{prevents} size reduction for the

21 ultrasonic motor and [hence increased factors to lower its]

22 reliability. ^{decreases the} ^{of the motor}

23 Accordingly, it is an object of the present invention to

24 provide ^a ultrasonic motor [which is decreased in factors to leak] ^{with reduced}

25 drive force produced on a piezoelectric element [and] efficiently ^{loss of} ^{so as to} the

1 transmit the drive force to a moving member, ^{and} wherein size
reduction and improvement in reliability are achieved.

SUMMARY OF THE INVENTION

4 [That is, the means to solve the problem is characterized
5 by a] ^{is provided that includes} ultrasonic motor, as claimed, comprises: a piezoelectric
6 vibrator for oscillating ^{In accordance with the present invention, an} [due to] an input drive signal, [and
7 generating] a drive force; and ^A a support member ^{in response to} [for supporting] supports
8 the piezoelectric vibrator on a substrate; wherein the support
9 member ^{also} [has a signal transmission function to transmit] ^{The} the drive
signal to the piezoelectric vibrator. ^{transmits}

11 [Here, the] ^{The} support member is formed, for example, of a resin
12 having on ^{its} [a] surface a signal line or ^{so as} [of a metal] to have a signal
transmission function. ^{it is formed}

14 [Meanwhile, the] ^{The} piezoelectric vibrator is formed, for
15 example, only by a piezoelectric element. Alternatively, ^{the piezoelectric} a vibrator
16 metal vibrator bonded to a piezoelectric element [may be applied ^{MAY be}
thereto]. The drive control may be either of a self-oscillation ^{formed}
17 type or a separately-oscillation type. ^{as}

According to this invention, because the drive signal is
transmitted through the support member to the piezoelectric
vibrator, there is no need to separately providing a signal
transmission part.

23 Accordingly, ^{loss of} the expansion-and-contraction vibration and
flex vibration caused on the piezoelectric vibrator is reduced

25 [in leak amount to an outside] as compared to the conventional. ^{ultrasonic}
motor

Therefore, the ultrasonic motor according to the invention efficiently transmits a drive force caused on the piezoelectric vibrator to the moving member.

Also, ^{in accordance with the present invention, there is no need for} [the unnecessary] of separately providing a signal transmission part [offers] size [reduction for] of the ultrasonic motor and [hence] ^{further thus decreasing the} decrease in the number of manufacture processes resulting in reduction in manufacture ^{decreasing the cost to} cost. ^{the inventive ultrasonic motor}

Next, the present invention is characterized in that, in the aforesaid ^{Also, in accordance with the present invention} ultrasonic motor, the support member [has elasticity], ^{is elastic} and the piezoelectric vibrator [being] ^{is} press-contacted with ^{the} a moving member by ^{the} an elastic force of the support member.

The ^{elastic} [method to provide the] support member [with elasticity] includes using as ^{is comprised of an elastic} a material, for example, a conductive rubber or the like.

[According to this invention, a function is available equivalent to that of the above invention.] In addition, the piezoelectric vibrator is urged ^{toward} [on] the moving member by the elasticity of the support member. Accordingly, the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

^{Also,} [Next, the present invention is characterized in that] ^{in accordance with the present invention} with the [aforesaid] ultrasonic motor, the support member has a constriction ^{portion} that is ^{connection} [made thin] than a portion connected to the piezoelectric vibrator. ^{thinner}

Accordingly,

1 [According to this invention, the provision of] (the
2 constriction ^{portion of} [in] the support member reduces the vibration
3 transmission area [in] ^{of} the support member so [that the
4 constriction reduces the leak] ^{as to reduce the loss} of vibration [furthermore].

Consequently, the ultrasonic motor transmits a drive force to
the moving member with higher efficiency. Furthermore, the
7 support member deforms due to the constriction ^{portion} [and has an
8 operation equivalent to that of the above invention].

9 Furthermore, ^{in accordance with} the present invention [is characterized in
10 that, in the aforesaid ultrasonic motor,] the support member is
a part of the substrate.

12 [According to this invention] ^{thus,} because the support member is ^a
13 [one] part of the substrate, the ultrasonic motor is easy to mount
on the substrate.

15 Furthermore, ^{in accordance with} the present invention [is characterized in
16 that, in the aforesaid ultrasonic motor,] the piezoelectric
vibrator is provided in a recess formed in the substrate.

18 [Here] ^{In accordance with this aspect of the invention} the piezoelectric vibrator is mounted such that the
surface of the substrate and the surface of the piezoelectric
vibrator are positioned in a same plane, through the support
21 member ^{formed a} [as one] part of the substrate [which has been left without
22 made in recess when forming a recess in the substrate].

23 [According to this invention, a similar operation is
24 available to that of the above invention.] In addition, [there
25 is decrease in] thickness of the ultrasonic motor, [plus the]
^{the} ^{inverted} ^{is decreased}

1 [substrate.] Accordingly the application of the ultrasonic motor
2 is broadened as compared to the conventional ultrasonic motor.]

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the piezoelectric vibrator is mounted on the support member.

6 According to this ^{aspect of the} invention, [a similar operation is
7 available to that of the above invention. In addition,] because

the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a

10 similar [procedure to] ^{manner as the} conventional mounting of transistors or

11 capacitors on a substrate. That is, in ^{(accordance with} the ultrasonic motor of the present invention, it is possible to simultaneously

mount a motor and circuits on a substrate by using an existing electric circuit production line. Accordingly, the ultrasonic

15 motor is [reduced in ^{less expensive and more stable} mounting cost and stabilized in mounting

16 process]. Consequently, the ^{invention} ultrasonic motor [is reduced in
17 variation of] ^{has better} performance, with improved reliability.
18 ^(characteristics)

19 Further, [the present invention is characterized in that,
in the aforesaid ultrasonic motor,] ^{in accordance with the present invention} the support member is provided with at least one part of a drive circuit.

21 According to this ^{aspect of the} invention, because the support member
22 is provided with at least part of a drive circuit, the ^{number of} drive

circuit elements required to be mounted on a substrate are decreased, thereby reducing the size of the ultrasonic motor.

Also, there is reduction of variation in ultrasonic motor

performance resulting from ^a connection between the piezoelectric vibrator and the drive circuit. Further, circuit parts can be mounted and adjusted so as to adjust the variation in the motor and circuits, thus improving the reliability.

Further, [the preset invention is characterized in that, in accordance with the ^{present invention}, in the aforesaid ultrasonic motor,] the support member supports the piezoelectric vibrator at a point corresponding to a node of vibration caused thereon.

Here, the vibration includes, for example, flex vibration and expansion-and-contraction vibration.

According to this ^{aspect of the} invention, the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration. Because there is no displacement in the node of vibration, there is further ^a decrease ^{in the} [in externally leaking] amount of vibration ^{loss} caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

Furthermore, [the present invention is characterized in that, in the aforesaid ultrasonic motor,] ^{in accordance with the present invention} the ultrasonic motor is an electronic appliance having the aforesaid ultrasonic motor.

According to this ^{aspect of the} invention, because the aforesaid ultrasonic motor is used in which less vibration [leaks to an] ^{is lost} outside as compared to the conventional ultrasonic motor, the

has increased, efficiency
1 ultrasonic motor [is increased in] output. That is, because the
ultrasonic motor and its drive circuit are reduced in size, the
electronic appliance with ultrasonic motor is decreased in
size.

BRIEF DESCRIPTION OF THE DRAWINGS

6 Fig. 1 is a view showing a structure of [a] ^{an} ultrasonic motor
7 [1] according to a first embodiment of the present invention;

9 Fig. 2 is a view showing a structure of a piezoelectric
10 vibrator [14] and piezoelectric vibrator [15] with electrodes [13a
11 to 13f] used in a piezoelectric element [10] for the ^{inventive} ultrasonic
motor [1];

12 Fig. 3 is a schematic view showing ^{the} operation of the
13 ultrasonic motor [1];

14 Fig. 4 is a view showing structural ^{essential} elements of
15 [a ultrasonic motor 2 as] a modification to the ultrasonic motor
16 [1]; ^{inventive}

17 Fig. 5 is a view showing a structure of [a] ^{an} ultrasonic motor
18 [3] according to a second embodiment of the present invention;

19 Fig. 6 is a view showing structural ^{essential} elements of
20 [a ultrasonic motor 4 as] a modification to the ultrasonic motor
21 [3]; ^{as shown in Fig. 5,} and

22 Fig. 7 is a view showing a structure of an electronic
23 ^{constructed} appliance with ^{an} ultrasonic motor [5] according to a third
embodiment of the present invention;

DETAILED DESCRIPTION OF THE INVENTION

Embodiments ^(of the present invention) will be explained in detail [to which the invention is applied,] with reference to Fig. 1 to Fig. 7.

Fig. 1 to Fig. 3 are figures for explaining ^{(a) an} ultrasonic motor 1 as a first embodiment of the invention, while Fig. 4 is a figure showing a structure of a ultrasonic motor 2 ^{(as a configured} modification of the ultrasonic motor 1.

[Meanwhile,] Fig. 5 is a figure for explaining ^{(a) an} ultrasonic motor 3 ^(second embodiment of the invention) [as a second embodiment of the invention], while Fig. 6 is a figure for explaining ^{(a) an} ultrasonic motor 4 ^{(as a configured} modification of the ultrasonic motor 3.

[Meanwhile,] Fig. 7 is a figure for explaining an electronic appliance 5 with a ultrasonic motor as a third embodiment of the invention.

[EMBODIMENTS]

[First Embodiment]

Fig. 1 is a view showing ^{(an) the} overall structure of ^{(a) the} ultrasonic motor 1.

As shown in Fig. 1 the ultrasonic motor 1 ^(is structured) [by] ^(includes) a piezoelectric element 10 (piezoelectric vibrator) that ^(is) inputted by ^(receives a) drive signal X, such as a sine wave, to elliptically vibrate, support members 11, 11 ^(support members 11) that hold the piezoelectric elements 10 on a substrate 7 and deliver signals through signal lines 7a, 7b on the substrate 7 ^(A) a symmetry member 12 ^(having) has a moving member 12a contacted with an end face of the piezoelectric element 10 ^(A) and a drive IC 6 ^(is) provided on the

substrate 7 to input drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and the support members 11, 11. Incidentally, the drive IC 6 outputs drive signal X to a predetermined portion of an electrode of the piezoelectric element 10, [hereinafter referred to,] according to a forward drive command, backward drive command and stop command [to be] externally inputted through signal lines 7c, 7d and 7e.

[That is,] the ultrasonic motor 1 [is a ultrasonic motor which] causes elliptic vibration at the piezoelectric member 10 end face according to drive signal X given from the drive IC 6 thereby moving the moving member 12a in directions parallel to the end face.

[First, the support members 11 are explained in detail.]

The support members 11 are formed of a resin, for example, generally in a L-form and each having, for example, three signal lines on a surface. That is, the support members 11, 11 have, for example, [totally] 6 signal lines which [number] is same as the number of electrodes provided on the side faces of the piezoelectric element 10.

The support member 11 has one side 11a fixed [on] the signal line 7a of the substrate 7, for example, through solder. Also, the support member 11 has the other side 11b fixed on a side face of the piezoelectric element 10, for example, through conductive adhesive in a manner holding a node of flexional vibration.

1 [Meanwhile, the signal lines 7a, 7b are a bundle of three signal lines. This number of signal lines is the same as the number of electrodes provided on the piezoelectric element 10 one side face, hereinafter referred to, which signal lines are separately connected respectively to signal lines of the support member 11.

7 [Due to this, the ^{The} support member 11 supports the piezoelectric element 10 on the substrate 7 and connects between the electrodes of the piezoelectric element 10 and the signal line 7a or signal line 7b.

13 In this manner, the support member 11 formed with the signal line also serves as a signal transmission means to ^{Thus} transmit a signal to the piezoelectric element 10. [That is, the number of parts connected to the piezoelectric member 10 is reduced and ^{hence} the ultrasonic motor 1 is made smaller in size.

15 Next, the piezoelectric element 10 will be explained in detail.

20 The piezoelectric element 10 has a piezoelectric vibrator 14 ^{provided} (as a flex vibration source laminated thereon with a piezoelectric vibrator 15 as an expansion-and-contraction vibration source in one body, and is structured having an electrode 13a, electrode 13b, electrode 13c, electrode 13d, electrode 13e and electrode 13f.

These electrodes 13a to 13f are respectively connected to the 6 signal lines provided on the support members 11, 11', and voltages are to be individually applied thereto.

Incidentally, a projection may be formed ^{approximately in the center of} [in] the piezoelectric element 10 [at generally center] to contact with and drive the moving member 12a.

[Here, the] ^{The} piezoelectric vibrator 14, 15 and the electrodes 13a to 13f will be explained in detail, with reference to Fig.

2.

Fig. 2(a) is a view showing an arrangement of electrodes [in] ^{on} one face of the piezoelectric element 10. [Meanwhile,] Fig

2(e) is a view showing an [arranging position] ^{arrangement} of electrodes in the side face 10a (see (a) of the figure), while (f) of the figure is a view showing an [arranging position] ^{the arrangement} of electrodes in side face 10b (see (a) of the figure).

[Meanwhile,] Fig. 2(b) is a view showing one surface of the piezoelectric vibrator 14, while (d) of the figure shows the other surface of the piezoelectric vibrator 15. [Meanwhile,] Fig. 2(c) is a top view of the piezoelectric vibrator 15.

[First explained is a] ^A polarization structure [in] ^{of} each piezoelectric vibrator. ~ will next be explained

The piezoelectric vibrator 14 is structured, as shown in Fig. 2(b), [of] divided into two in a vertical direction and also ^{divided into} two in a horizontal direction [into four], i.e. a polarization region 14a, a polarization region 14b, a polarization region

14c and a polarization region 14d that are to be polarized + at their top surfaces in a laminated direction.

Meanwhile, the piezoelectric vibrator 15 is structured, as shown in Fig. 2(d), having one polarization region almost

5 [in] ^{on} an entire surface so that it can be polarized +, for example,
6 [in] ^{on} an underside ^{surface} in the lamination direction.

7 Next [explained are] ^{the} structures of the electrodes 13a to
8 13f. ~ will be explained.

9 The electrode 13a [almost] ^{substantially} covers [over] a top surface of the polarization region 14a of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the
12 polarization regions 14a, ^{etc.} 14a ... of a plurality of
13 piezoelectric vibrators 14, 14 ..., at the top surfaces, are
14 [to become] ^{brought to} a same potential by the electrode 13a continuing through extended portions to the side face 10b.

16 Similarly, the electrode 13b [almost] ^{substantially} covers over one surface of the polarization region 14b of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14b, 14b ... of the
19 plurality of piezoelectric vibrators 14, 14 ..., at the one
20 surfaces, are ^{are brought to} to become a same potential by the electrode 13b continuing through extended portions to the side face 10b.

23 Meanwhile, the electrode 13c [almost] ^{substantially} covers over [one] a surface of the polarization region 14c of the piezoelectric vibrator 14, one part of which is extended to a side face 10b.

1 That is, all the polarization regions 14c, 14c ... of the
2 plurality of piezoelectric vibrators 14, 14 ..., at the one
3 surfaces, [are to become] ^{are brought to} a same potential by the electrode 13c
continuing through extended portions to the side face 10a.

5 Similarly, the electrode 13d [almost] ^{substantially} covers over one
surface of the polarization region 14d of the piezoelectric
element 14, one part of which is extended to a side face 10b.

8 That is, all the polarization regions 14d, 14d ... of the
9 plurality of piezoelectric vibrators 14, 14 ..., at the one
10 surfaces, [are to become] ^{are brought to} a same potential by the electrode 13d
continuing through extended portions to the side face 10a.

12 Also, the electrode 13e [almost] ^{substantially} covers over the other
surface of the polarization region 15a of the piezoelectric
vibrator 15, one part of which is extended to a side face 10a.

15 That is, all the polarization regions 15a, 15a ... of a
16 plurality of piezoelectric vibrators 15, 15 ..., at the other
17 surfaces, [are to become] ^{are brought to} a same potential by the electrode 13e
continuing through extended portions to the side face 10a.

Further, the electrode 13f is sandwiched between the other
surface of the piezoelectric vibrator 14 and the one surface
of the piezoelectric vibrator 15. Consequently, the electrode
13f covers over all the undersides of the four polarization
regions 14a, 14b, 14c and 14d of the piezoelectric vibrator 14,
and at the same time over the entire top surface of the
25 polarization region 15a of the piezoelectric vibrator 15, [and]

part of which is extended to the side face 10b. That is, all
2 the polarization regions 14d, 14d ... of the plurality of
3 piezoelectric vibrators 14, 14, at the top surfaces, ^{brought} are to
4 [become] a same potential by the electrode 13f continuing through
the extended portions to the side face 10b.

Incidentally, the number of the piezoelectric vibrators
14, 15 may be increased appropriately. In this case, the
electrode structure is changed depending on a lamination
method.

Now, the operation of the ultrasonic motor 1 is explained
using Fig. 3.

If the drive IC 6 is externally inputted by a drive command
signal in a positive direction through the signal line 7c shown
in Fig. 1, it outputs a drive signal X to the electrodes 13a,
13d, 13e and 13f of the piezoelectric element 10 through the
signal lines 7a, 7b and the aforesaid signal lines on the
support member 11.

Thereupon, in the piezoelectric vibrator 15 the drive
signal X is inputted to the electrode 13e with respect to the
electrode 13f as a reference electrode. Accordingly, the
polarization region 15a expands or contracts. Consequently, the
piezoelectric vibrator 15 expands or contracts in a lengthwise
23 direction as shown by ^{rectangle} a rectangular 15' in Fig. 3.

Simultaneously, in the piezoelectric vibrator 14 the
drive signal X is inputted to the electrodes 13a, 13d with

respect to the electrode 13f as a reference electrode. Accordingly, the polarization regions 14a, 14d expands. Consequently, the piezoelectric vibrator 14 effects flexional vibration as shown by [a rectangular] 14' in Fig. 3.

At this time, the ^{only} members connected to the piezoelectric element 10 [is only] the support members 11, 11'. Because no signal transmission means is separately provided, vibration [leak] ^{loss} is reduced from the piezoelectric element 10.

As a result, the expanding-and-contracting vibration on the piezoelectric vibrator 15 and the flexional vibration on the piezoelectric vibrator 14 are combined so that the piezoelectric element 10 at the end face effects elliptic vibration in a Z direction in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in the Z direction as a positive direction.

Also, if the drive IC 6 is externally inputted by a drive command in a reverse direction through the signal line 7d, it outputs a drive signal X to the electrodes 13b, 13c, 13e and 13f of the piezoelectric element 10 through the signal lines 7a, 7b and the aforesaid signal lines on the support member 11.

Thereupon, because the electrodes 13b, 13c are inputted by the drive signal X, the flex vibration of the piezoelectric vibrator 14 with respect to the expanding-and-contracting vibration as a reference of the piezoelectric vibrator 15 is reversed in direction from the positive direction case as

stated above. Accordingly, the piezoelectric element 10 at the end face effects elliptic vibration in a direction reverse to Z in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in a reverse direction.

5 As described above, according to ^{a first embodiment of} the ultrasonic motor 1 ^{invention}
6 { as a first embodiment of the present invention, because the drive signal X is delivered to the piezoelectric element 10 through the signal line 7a by the support member 11, there is no necessity of separately providing a signal transmission
10 part. Accordingly, the ^{loss of the} expanding-and-contracting vibration
11 and flex vibration ^{caused} [caused] on the piezoelectric element 10 [are
12 reduced in amount of leak to an outside], ^{is reduced} as compared to the
13 conventional. ^{ultrasonic motor} Also, because the support members 11 are fixed
14 in a manner holding a flex vibration node, the ^{loss of the} flex vibration
15 caused on the piezoelectric element 10 is further reduced, [in
16 amount of leak to an outside.]

Further, because there is no necessity of separately providing a signal transmission part, the ultrasonic motor 1
17 is reduced in size, ^{along with} and also the number of manufacture processes, thereby
20 reducing manufacturing costs.

Accordingly, the ultrasonic motor 1 effectively transmits a drive force generated on the piezoelectric element 10 to the moving member 12a.

24 Incidentally, in ^{this} [the] embodiment of the present invention, although the support member 11 was made of a resin, the present

invention is not limited to this and may be of a metal, for
2 example. In this case, the ^{number of} support members 11 has to be provided
corresponding to the number of electrodes.

Further, the support member 11 may be provided with an
entire or [one part of an electric circuit, e.g. self-
oscillation transmitting circuit. In this case, the number of
7 elements to be provided on the substrate decreases, ^{and} the ^{required}
8 substrate area [required] decreases. Accordingly, the
ultrasonic motor 1 is further reduced in size.

10 [Incidentally, the ^{The} present embodiment may be modified as
below.

Fig. 4 is a view showing a structure of elements of a
ultrasonic motor 2 of a first modification to the present
embodiment.

The ultrasonic motor 2 is made by a structure, in the
ultrasonic motor 1, using support members 21 in place of the
support members 11.

18 The support members 21 ^{are} [is] formed with a constriction in a
generally I-form in the support member 11 with other parts
20 structured similar to those of the support member 11. [That is, ^{Thus}
21 the support members 21 possess ~~the~~ elasticity. Also, the support
members 21 are fixed at side faces of the piezoelectric element
10 so that they can deflect in a direction parallel to the side
face of the piezoelectric element 10.

1 Accordingly, the support members 21 press^{ed} the
2 piezoelectric element 10 against the moving member 12a
3 (omittedly) ^{not} shown in Fig. 4).

4 That is, the ultrasonic motor 2 ^{has} [as] an equivalent function
5 [to] ^{as} the ultrasonic motor 1. Further, because the piezoelectric
7 element 10 is put in pressure contact with the moving member
12a by the support members 21, there is ^{an} increase of frictional
force acted on between the piezoelectric element 10 and the
moving member 12a. Accordingly, the drive force caused on the
piezoelectric element 20 is conveyed to the moving member 12a
with higher efficiency.

13 Also, the provision of the constriction decreases a
vibration transmission area, further decreasing [leak] ^{the loss} of
vibration through the support member 21. Accordingly, the
ultrasonic motor 2 transmits a drive force to the moving member
12a with higher efficiency.

Incidentally, the method of providing elasticity to the
support member 21 includes a method of forming a support member
21 of a conductive rubber with the shape of the support member
11 used as it is.

Also, the support member 21 may be provided with an entire
or part of an electric circuit such as a self-oscillation
transmitting circuit.

24 ([Second Embodiment])

Fig. 5 is a view showing a schematic structure of elements
2 of a ^{second embodiment of the invention} ultrasonic motor 3.

3 The ultrasonic motor 3 is made ^{in a structure} [in] a structure [that] ^{with} the
5 piezoelectric element 30 is mounted on a substrate 8 having a
recess by [using] support members 8b, 8b that are provided as [one]
portions of the substrate 8 in the recess. Also, as shown in
7 Fig 5(b), the piezoelectric member 30 has a top surface [almost] ^{substantially}
in a same plane as that of a top surface of the substrate 8.
9 Incidentally, other [not-shown] structural constituents ^{are} ~~that are not~~
10 [almost] ^{substantially} the same as those of the ultrasonic motor 1. ^{shown}

The support member 8b is structured, as shown in Fig 5(a),
to have a support portion for holding the piezoelectric element
30 at a tip end of a terminal extended from the substrate 8.
Due to this, the support member 8b is generally in a T-form in
section in a parallel direction with the substrate 8. This
16 substrate 8 is formed [in] ^{having} a predetermined form, for example, by
17 [previously] preparing a forming mold for [a] ^{the Fig 5} substrate 8 in a
18 corresponding shape to [this] Also, as shown in (b) [of the
19 figure], the support portion ^{as a convex portion to support an}
^{is formed} underside of the piezoelectric element 30. [Meanwhile, one] ^{one}
20 support member 8b has at a top face a signal line 8a to be
connected to a part of the electrodes of the piezoelectric
element 30, while the other support member 8b has at a top face
24 a signal line 8a, 8a' to be connected to the remainder of the
electrodes of the piezoelectric element 30. Incidentally, the

number of the signal lines 8a or support members 8b or their forming positions may be appropriately changed in accordance with the number of electrodes on the piezoelectric element 30 or a vibrational node position.

5 Here, the support member 8b is provided so ^{that} [that] it holds a flex vibration node on the piezoelectric element 30, similarly to the support member 11.

The piezoelectric element 30 has almost the same structure as that of the piezoelectric element 10 except for a structure of extending electrodes to end faces 30a, 30b.

Here, when required, a signal line is passed through a hole 8d opened in the substrate 82 so that the signal line is connected to an electrode provided on a backside of the piezoelectric element 30.

That is, if a drive signal X is inputted through signal lines 8a, 8a, 8a' to the electrodes of the piezoelectric element 30, the piezoelectric element 30 at the end face effects elliptic vibration to thereby move the moving member (not shown) that is in contact with the end face.

As described above, because in the ultrasonic motor 3 the
21 support members 8b, 8b serves also as a signal transmitting
22 means alike in the ultrasonic motor 1, the ^{loss of the} expanding-and-
23 contracting vibration and flex vibration [occurred] ^{Receiving} on the
24 piezoelectric element 30 is reduced [in leak amount to an outside]
25 as compare to the conventional. Further, because the support
ultrasonic motor

members 8b are provided in a manner holding a flex vibration
2 node, the (flex vibration caused on the piezoelectric element
3 is further reduced ^{loss of the} [in leak amount to the outside].

Accordingly, the ultrasonic motor 3 can efficiently
transmit the drive force caused in the piezoelectric element
30 to the moving member.

Also, because the piezoelectric element 30 is provided in
the recess of the substrate 8 such that the piezoelectric
element 30 and the substrate 8 at their top surfaces are in a
same plane, the total thickness of the ultrasonic motor 3 and
the substrate 8 are decreased, making the size small.
Consequently, the application range of the ultrasonic motor 3
broadens as compared to that of the conventional ultrasonic
motor.

Incidentally, the support member 8b may be formed with a
constriction in a manner similarly to the support member 21,
17 or the support member 8b [only] may be formed of conductive
rubber. In this case, because the piezoelectric element 30 is
pressed against the moving member by the support member 8b,
20 [there obtains] ^{2a} further increase in the transmission efficiency
21 of drive force to the moving member. ^{"obtained"}

Furthermore, the support member 8b may be provided with
22 an entire or [one] part of an electric circuit such as a
self-oscillation generating circuit. In this case, the number
23 of elements on the substrate ^{is decreased} [decreases] to [decrease a] substrate
reducing the required

area [required]. Accordingly, the ultrasonic motor 3 is made further smaller. ^{in size}

{ Incidentally, the ^{The} present embodiment may be ^{further} modified as follows.

Fig. 6 is a view showing a schematic structure of essential elements of a ultrasonic motor 4 of a first modification according to the present embodiment. Incidentally, the structural constituents not shown are [in almost] the same structure as those of the ultrasonic motor 1. ^{substantially}

In Fig. 6, the ultrasonic motor 4 is structured such that the piezoelectric element 40 is fixed, corresponding to nodes of flex vibration of the piezoelectric element 40, on surfaces of the support members 8c, 8c ... provided in a recess of a substrate 8 using, for example, solder, as shown in Fig. 6(b).

The support member 8c is structured having a [support] piezoelectric element 40 support portion provided at a tip of an extension terminal extended from the substrate 8, as shown in Fig. 6(a). The support portion has a top face that is [flush] flush with the top face of the substrate 8. Due to this, the sectional [form] ^{shape} in a parallel direction to the substrate 8 is generally a T form.

Also, a predetermined signal line 8a is provided on a surface of the support member 8c corresponding to an electrode of the piezoelectric element 40. Incidentally, the number of signal lines 8a, and the number and position of support members

8c are appropriately changed depending on the number of electrodes of the piezoelectric element 40 or the position of vibration node.

4 The piezoelectric element 40 is structured generally ^{the} same as the piezoelectric element 10 except for an electrode extended to an end face.

7 As described above, in ^{accordance with} the ultrasonic motor 4 ^{invention} [reduced is
8 leak amount to the outside of] the expansion-and-contraction and
9 flex vibration caused on the piezoelectric element 40 ^{loss of the} as ^{reduced}
10 compared to the conventional [similarly to the] ultrasonic motor
1. Furthermore, because the support member 8c is provided in
a manner holding a flex vibration node of the piezoelectric
13 element 40, [further reduced is the leak] ^{the / of loss of} amount ^{to the} [outside
14 of] flex vibration caused in the piezoelectric element 40. ^{further reduced}

Accordingly, the ultrasonic motor 4 efficiently delivers a drive force produced on the piezoelectric element 40 to the moving member.

Also, the piezoelectric element 40 is mounted through solder on the surfaces of the support members 8c. Accordingly, where for example the circuit board 8 is formed by a printed board, it is possible to mount the piezoelectric element 40 on the circuit board 8 in a similar procedure to conventional mounting of a transistor or capacitor on the board. That is, the ultrasonic motor 4 allows on-board mounting using an

existing electric circuit production line, reducing mounting cost and improving reliability.

Incidentally, the support member 8c may be provided with a constriction similarly to the support member 21 or the support member 8c only may be formed of a conductive rubber. In this case, because the piezoelectric element 40 is pushed against the moving member by the support member 8c, the transmission efficiency of drive force to the moving member further improves.

Also, the support member 8c may be provided with an entire or one part of an electric circuit, such as a self-oscillation circuit.

13 [Third Embodiment]

14 Fig. 7 is a block diagram ^{illustrating} [of] an electronic appliance [with] ^{incorporating} an embodiment ^{of the} ultrasonic motor 5 ^{inventive} that the ultrasonic motor of the present invention is applied to an electronic appliance.]

15 An electronic appliance with ^{an} ultrasonic motor 5 is
16 realized by providing a piezoelectric element 51 treated by ^{na}
17 predetermined polarization process, a vibration member 52
18 joined to an piezoelectric element 51, a moving member 53 to
be moved by the vibration member 52, a pressurizing mechanism
54 for applying pressure to the vibration member 52 and moving
member 53, a transmission mechanism 55 movable interlinked to
the moving member 53, and an output mechanism 56 to be moved
based on operation of the transmission mechanism 55.

Incidentally, the pressurizing mechanism 54 is, for example,

^{provided}
by the support member 21.

Here, the electronic appliance ^{incorporating an embodiment of the invention} [with] ultrasonic motor 5 includes, for example, electronic timepieces, measuring instruments, cameras, printers, printing machines, machine tools, robots, moving apparatuses, memory devices and so on.

Also, the piezoelectric vibrator 51 uses, for example, piezoelectric elements 10, 20, 30. Also, the transmission mechanism 55 uses, for example, a transmission wheel, such as a gear, friction wheel, or the like. The output mechanism 56 uses, for example for a camera, a shutter drive mechanism or lens drive mechanism, and for an electronic timepiece, a pointer drive mechanism or calendar drive mechanism. Where used in a memory device, a head drive mechanism for driving a head to read and write information from and to a memory medium within the information memory device. For a machine tool, a tool feed mechanism or work feed mechanism is used.

^{The} [Because this] electronic appliance ^{incorporates an} [with] ultrasonic motor 5 ^{constructed in} [uses a ultrasonic motor] according to the invention having a higher output as compared to the conventional ultrasonic motor, and thus the ultrasonic motor and its drive circuits are reduced in size.

^{the electronic appliance} Accordingly, [it] is smaller in size as compared to [the] a similar conventional electronic appliance. Also, where a self-oscillation drive is employed as a method to drive the

ultrasonic motor, it is possible to further reduce the size for the electronic appliance ^{incorporating an inventive} [with] ultrasonic motor 5.

^{Further} [Incidentally, if an output axis is provided to the moving member 53 to make a structure having a power transmission mechanism ^{for transmitting} to transmit torque through the output axis, a drive mechanism is ^{obtained using} [structured by] a single ultrasonic motor.

According to this invention, because the drive signal is transmitted through the support member to the piezoelectric vibrator, there is no need to separately ^{provide} [providing] a signal transmission part. Accordingly, the ^{loss of the} expansion-and-contraction vibration and flex vibration caused on the piezoelectric vibrator is reduced ^{in leak amount to an outside} [in leak amount to an outside] as compared to the conventional. Therefore, the ultrasonic motor according to the ^{ultrasonic motor} invention efficiently transmit a drive force caused on the piezoelectric vibrator to the moving member. ^{present}

^{in accordance with the present invention} Also, ^{the necessity} [the unnecessary] of separately providing a signal transmission part ^{is avoided thus} [offers size reduction for] the ^{inventive} ultrasonic motor and ^{reducing the size of} hence decrease in the number of manufacture processes resulting in ^{decreasing} reduction in manufacturing cost.

^{Further} [Further, according to this invention, a function is available equivalent to that of the above invention. In addition, ^{In accordance with the present invention,} the piezoelectric vibrator is urged on the moving member by the elasticity of the support member. Accordingly,

the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

Further, according to this invention, the provision of the constriction in the support member reduces the vibration transmission area ^{in the support member so that the} constriction ^{and reduces vibration loss,} reduces the leak of vibration furthermore.]

Consequently, the ultrasonic motor transmits a drive force to the moving member with higher efficiency. Furthermore, the support member has elasticity due to the constriction, and has an operation equivalent to that of the above invention.

Further, ^{in accordance with the present invention,} according to this invention, because the support member is ^{one} part of the substrate, the ultrasonic motor is easy to mount on the substrate.

[Further, according to this invention, a similar operation is available to that of the above invention.] In addition, ^{in accordance with the present invention,} there is ^a decrease in thickness of the ultrasonic motor plus the substrate. ^{the} Accordingly the application of the ultrasonic motor is broadened as compared to the conventional ultrasonic motor. ^{a compared with the conventional art}

[Further, according to this invention, a similar operation is available to that of the above invention.] In addition, because the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a similar procedure to conventional mounting of transistors or capacitors on a substrate. That is, ^{in accordance with} in the ultrasonic motor of the present invention, it is possible to

simultaneously mount a motor and circuits on a substrate by using an existing electric circuit production line.

8 Accordingly, the ^{invention} ultrasonic motor ^{lower} [is reduced in] mounting cost and [stabilized in] ^{a more stabilized} mounting process.

7 Further, according to this invention, because the support member is provided with at least part of a drive circuit, there is ^a reduction ^{in the} [of] variation in ultrasonic motor performance resulting from mounting of the piezoelectric vibrator and the drive circuit, improving the reliability.

13 Further, according to this invention, because the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration, there is further ^a decrease in externally [leaking amount of] ^{lost} vibration caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

14 Further, according to this invention, because the aforesaid ultrasonic motor is used in which less vibration leaks to an outside ^{is lost} as compared to the conventional ultrasonic motor, the ultrasonic motor is increased in output. That is, the ultrasonic motor and its drive circuit are reduced in size, hence the electronic appliance with ultrasonic motor is decreased in size.